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CORRELATIONS BETWEEN STRUCTURAL AND MORPHOGENETIC CHARACTERISTICS ON SIGNAL GRASS PASTURES

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ABSTRACT

The analysis of both morphogenetic and structural characteristics of pasture allows us to understand the response patterns of the plant to the environment. Thus, this study was conducted to evaluate the associations among the morphogenetic and structural characteristics of Brachiaria decumbens under continuous grazing by cattle. The development of individual tillers in pastures was evaluated under two grazing management strategies during three seasons (winter, spring and summer). Pearson correlations between variables were estimated. The lengths of leaf and stem, number of tillers and leaves per tiller, rates of leaf appearance and elongation of leaf and stem of B. decumbens were positively correlated. There was a negative relationship between appearance and lifespan of leaves (r = -0.89). However, positive correlations between leaf appearance rate and number of tillers (r = 0.64) and between length of stem and leaf senescence rate (r = 0.63) were determined. The B. decumbens modifies its morphogenesis to better adapt to climate and grazing management.

KEYWORDS: *Brachiaria decumbens*; climate, grazing; growth; senescence.

CORRELAÇÕES ENTRE CARACTERÍSTICAS MORFOGÊNICAS E ESTRUTURAIS EM PASTOS DE CAPIM-BRAQUIÁRIA

RESUMO

A análise conjunta das características morfogênicas e estruturais do pasto permite compreender os padrões de respostas das plantas ao ambiente. Dessa forma, este trabalho foi conduzido para avaliar as associações entre as características morfogênicas e estruturais da *Brachiaria decumbens* sob lotação contínua com bovinos. Foi avaliado o desenvolvimento de perfilhos individuais em pastos mantidos sob duas estratégias de manejo do pastejo, durante três estações do ano (inverno, primavera e verão). Correlações lineares de Pearson entre as variáveis respostas foram estimadas. Os comprimentos da lâmina foliar e do colmo, os números de perfilhos e de folhas vivas por perfilho, as taxas de aparecimento foliar e de alongamento de folha e de colmo da *B. decumbens* foram positivamente correlacionados. Houve relação negativa entre aparecimento e duração de vida das folhas (r = -0,89). Porém, correlações positivas entre taxa de aparecimento foliar e número de perfilho (r = 0,64) e entre comprimento do colmo e taxa de senescência foliar (r = 0,63) foram determinadas. A *B. decumbens* modifica sua morfogênese para melhor adaptação às condições do clima e do manejo do pastejo.

PALAVRAS-CHAVE: *Brachiaria decumbens*; clima; crescimento; pastejo; senescência.

INTRODUCTION

The durability and productivity of pasture are due to the continuous emission of leaves and tillers, important processes for the restoration of leaf area after defoliation. Leaf development is essential to plant growth, considering leaves´ role in photosynthesis, the starting point for tissue synthesis (PARSONS et al., 1983).

Stem development also influences forage production because, depending on the development stage of the tiller, the stem has priority in the photoassimilated partition. Moreover, the stem can promote the photosynthesis of the canopy by reducing their light extinction coefficient (FAGUNDES et al., 2001).

A better understanding of the dynamics of forage production on pasture can be obtained by the study of morphogenesis. In pastures where only leaves are produced, the morphogenesis of plants can be described by three main characteristics: leaf appearance rate, leaf elongation rate and leaf lifespan. The combination of morphogenetic characteristics determines the three main structural characteristics of the pasture: leaf size, tiller density and number of live leaves per tiller (CHAPMAN & LEMAIRE, 1993).

It is worth mentioning that, on tropical pastures, stem elongation is also an important morphogenetic characteristic because it determines other structural characteristics that influence decisively pasture primary and secondary production, such as the size of the stem (SANTOS et al., 2011) and the leaf blade / stem ratio (CÂNDIDO et al., 2005).

Alterations in plant morphogenesis determine changes in the structural characteristics of the pasture, i.e., changes in the way the canopy organs are arranged in time and space. This changes the microclimate (e.g., ventilation, temperature, humidity, light), in which the plants grow and, consequently, generates new morphogenetic changes in the pattern of the plant. All these processes characterize the complex and interdependent nature of the dynamics of plant populations and tissue flow on pasture ecosystem. Thus, the study of correlations is important because it identifies the nature of the associations among the variables of the plant morphogenesis.

Additionally, the interpretation of the morphogenetic responses of the plant allows establishing whether seasonal grazing management, characterized by the adoption of different pasture heights between seasons, is advantageous when compared to similar grazing management between the seasons.

Therefore, the aim of this work was to evaluate the association between morphogenetic and structural characteristics of *Brachiaria decumbens* managed under continuous stocking during three seasons.

MATERIAL AND METHODS

The experiment was conducted from June 2008 to March 2009 on *Brachiaria decumbens* cv. Basilisk (Stapf.) (signal grass) pasture, belonging to the Forage Section of the Department of Animal Science, Universidade Federal de Viçosa (UFV) - MG (20 º 45 'S, 42 º 51' W, 651 m). Signal grass pasture established in Oxisol clayey soil and moderately undulating topography (EMBRAPA, 1999) was used. The pasture was already divided into eight paddocks, 0.25 to 0.40 ha, and there was also a reserve area, totaling approximately 3.0 ha, before the experiment implementation.

The climate of the region of Viçosa, according to the Köppen system (1948), is Cwa, with annual rainfall around 1340 mm and average relative humidity at 80%. The average maximum and minimum temperatures are 22.1 and 15^{o}C. Climatic data recorded during the experimental period were obtained from the meteorological station of the Agricultural Engineering Department at UFV, situated about 500 m from the experimental area (Table 1).

Table 1 - Monthly averages of daily mean temperature, insolation, monthly total rainfall and monthly total evaporation from June 2008 to March 2009

Month	Mean air temperature (°C)	Insolation (hour/day)	Rainfall (mm)	Evaporation (mm)
June/2008	16.7	6.2	12.7	55.9
July/2008	15.4	8.2	10.2	73.9
August/2008	16.7	7.3	15.4	87.1
September/2008	18.7	4.4	150.0	101.5
October/2008	21.6	5.6	41.4	89.0
November/2008	21.0	3.7	223.8	65.8
December/2009	21.3	11.1	626.0	270.8
January/2009	22.5	13.2	250.7	137.0
February/2009	23.0	6.6	222.5	63.3
March/2009	22.8	5.8	231.9	60.1

Two grazing management systems were evaluated. In one system, pasture was maintained at 25 cm high throughout the experimental period. In the other system the pasture was kept at 15 cm high during the winter, and it was increased to 25 cm from the beginning of the spring on. A split plot arrangement and a randomized block design with four replications were used. The grazing management strategies matched the primary factor (plot), characterized by average heights where the pastures were kept under continuous stocking during the seasons (winter, spring and summer). The seasons corresponded to the secondary factor (subplots) and consisted of measures throughout the experimental period.

Since June 2007, the eight plots of the experimental area had been grazed under continuous stocking with variable stocking rate to maintain the average pasture height at 25 cm. Thus, for the implementation of the treatments in mid-June 2008, the average height of pasture in the four paddocks previously described was lowered to 15 cm. For this, the stocking rate capacity of the pasture was increased, by using cattle in growing phase with an average weight of about 200 kg. Thus, it was possible to achieve the target height (15cm) within a period of 15 days. The other four paddocks, on the other hand, remained at about 25 cm high, without any animals since May 2008. From the beginning of October 2008 on, all paddocks were grazed concomitantly, and the pastures were managed under continuous stocking with variable stocking rate to maintain their average height about 25 cm.

The monitoring of pasture heights was carried out by measuring each paddock at 50 points, by using the tool and methodology described by SANTOS et al. (2011). To control the pasture height, cattle with 200 kg of body weight were removed or placed in paddocks when pasture heights were below or above the target value, respectively.

The fertilizer management was based on soil chemical analysis performed in October 2008, which showed the following results: pH in H_2O: 4.79; P: 1.5 (Mehlich-1); K: 86 mg/dm^3; Ca^{2+}: 1.46; Mg^{2+}: 0.32 and Al^{3+}: 0.19 cmol$_c$/dm^3 (KCl 1 mol/L). Fertilization was performed in all experimental area with application of 100 kg / ha of N and K_2O, as well as 25 kg/ha of P_2O_5, using the formulated 20-05-20. These doses were divided into two equal applications, which occurred on November 11th 2008 and December 15th 2008.

From the beginning of July 2008 until the end of March 2009, the morphogenetic and structural characteristics of signal grass were evaluated in 16 tillers per experimental unit, according to the methodology described by SANTOS et al. (2011). The following variables were calculated based on these procedures: leaf appearance rate, phyllochron, leaf elongation rate, stem elongation rate, leaf senescence rate, leaf lifespan, leaf blade length, stem length, number of live and dead leaves per tiller and number of tillers per area.

The database generated from these morphogenetic assessments (SANTOS et al., 2011) was used to study the associations among the morphogenetic and structural characteristics of signal grass. The analyses of the experimental data were performed by using the Statistical Analysis

System for - SAEG, version 8.1 (UFV, 2003). Pearson linear correlations among the morphogenetic and structural characteristics were estimated by using 24 observations. All values were tested by t-test up to 10% probability.

RESULTS AND DISCUSSION

The values of morphogenetic and structural characteristics of signal grass (Table 2) used for the correlation study in this work showed that lowering the grass to 15 cm in winter resulted in higher leaf appearance rate and higher number of live leaves and tillers during this season. However, because of this management strategy, leaf lifespan, leaf senescence rate and leaf and pseudostem lengths were lower in winter compared to pasture at 25 cm. Moreover, in winter, leaf appearance and elongation rates, stem elongation rate, number of live leaves and tillers and leaf blade and pseudostem lengths were lower. On the other hand, leaf lifespan and the number of dead leaves were higher in the winter. The highest leaf senescence rate occurred in spring. Thus, *B. decumbens* cv. Basilisk pasture, under continuous stocking, can be seasonally managed, being lowered to 15 cm in the beginning of winter and then subsequently increased to 25 cm in the beginning of spring (SANTOS et al., 2011).

Regarding the association among the morphogenetic characteristics of the signal grass, leaf appearance rate (LAR) correlated positively with leaf and stem elongation rates (LER and SLR, respectively), but correlated negatively with leaf lifespan (Table 3). These results can be explained by taking into account the climatic conditions during the experimental period (Table 1).

Table 2 - Morphogenetic and structural characteristics of signal grass pastures managed under continuous stocking and with fixed or variable heights during the seasons

Characteristics	Pasture at 25 cm in all seasons			Pasture at 15 cm in the winter and 25 cm in spring and summer		
	Winter	Spring	Summer	Winter	Spring	Summer
LAR	0.01	0.10	0.11	0.02	0.11	0.12
PHYL	80.74	10.48	8.88	52.99	9.17	8.05
SER	0.01	0.24	0.30	0.01	0.23	0.35
LER	0.10	1.35	1.61	0.12	1.52	1.41
LSR	0.34	0.51	0.25	0.18	0.29	0.19
LLS	147.87	39.19	38.31	129.69	33.16	34.77
LBL	10.33	13.15	13.34	6.95	12.08	13.85
SL	18.26	23.55	19.55	8.70	16.97	20.05
NDL	2.13	1.76	1.16	1.94	1.62	1.16
NLL	2.39	4.81	5.38	3.42	4.64	5.46
NT	1578	1697	1951	1665	1980	2213

LAR-leaf appearance rate; PHYL-phyllochron; LER-leaf elongation rate; SER-stem elongation rate; LSR-leaf senescence rate; LLS-leaf lifespan; LBL-leaf blade length; SC- stem length; NLL-number of live leaves; NDL-number of dead leaves; NT-number of tillers.

Table 3 - Pearson linear correlations between morphogenetic characteristics of tillers in signal grass pasture under continuous stocking

Variable	LAR	PHYL	LER	SER	LSR	LLS
LAR	-	-0.94*	0.97*	0.94**	0.07	-0.89**
PHYL		-	-0.92*	-0.86**	0.08	0.94*
LER			-	0.93*	0.16	-0.86
LER				-	0.07	-0.80***
LSR					-	-0.17
LLS						-

LAR-leaf appearance rate; PHYL-phyllochron; LER-leaf elongation rate; SER-stem elongation rate; LSR-leaf senescence rate; LLS-leaf lifespan; *Significant by t test (P <0.01); **Significant by t test (P <0.05); ***Significant by t test (P <0.10).

In months when the climate was favorable for pasture growth (October-March), tissues flow in individual tillers was intense, because of the positive association among LAR and the rest of the pasture growth rates (LER and SER). On the other hand, adverse weather conditions during the winter (Table 1), such as lower temperature, reduced rainfall and reduced sunshine, limited tillers development and caused a concomitant reduction in LAR, LER and SER. In fact, tissues growth rate respond immediately to changes in temperature of the environment, so that the tissue production follows its seasonal variations (FAGUNDES et al., 2006; MORAES et al., 2006).

The negative relationship between LAR and leaf lifespan (LLS) (Table 3) reflects a compensatory mechanism of signal grass pasture in response to abiotic factors. In winter, there are restrictive conditions for pasture growth due to, among other factors, the decrease of nutrient availability for the forage plant mainly because of the drought in this time of year, which limits nutrients absorption by the plant via mass flow and diffusion in the soil (NOVAES & SMYTH, 1999). Under such conditions, signal grass reduces its growth rate, presenting lower LAR, LER and SER. However, in order to counteract these adverse effects to the formation of new leaf area on signal grass pasture, LLS was increased. This enabled an increase in the average permanence time of nutrients in the plant, and therefore, improved their retention in the vegetal organism (SANTOS et al., 2011).

It is important to emphasize that the efficiency of nutrients conservation, conferred by the high LLS of signal grass, is appropriate when the environment is characterized by less frequent defoliation (SANTOS et al., 2011), fact that happened in the winter, when signal grass pasture remained free from animals due to the maintenance of the intended heights.

In contrast, in spring and summer, seasons when the environmental factors of growth were restored (Table 1) and fertilization was performed, the maximization of growth (higher LAR, LER, and SER) resulted in a reduction of LLS. In fact, the low LLS has been recognized as a response marker of plans related to the condition of a favorable environment for growth, such as high soil fertility (WRIGHT et al., 2004).

The correlations of phyllochron with the other morphogenetic characteristics were contrary to those observed for LAR (Table 3), which is consistent, given that the phyllochron is the opposite of LAR.

Regarding the senescence rate (LSR), its correlations with the other signal grass morphogenetic characteristics were weak and non-significant (Table 3). These results can be justified by the inherent instability of the senescence process. Moreover, while the other characteristics showed typical and differentiated morphogenetic response patterns between the months of winter and the ones of spring and summer, LSR was high only during the spring, with lower values in winter and in summer (SANTOS et al. 2011).

As the morphogenesis determine the structural characteristics of the plant (CHAPMAN & LEMAIRE, 1993), it is relevant to understand the association between these response variables. Accordingly, it was found that, generally, the structural features descriptors of the greatest grass growth (leaf blade length, stem length, number of live leaves per tiller, number of tillers) were positively correlated with the morphogenesis which show increased flow of plant tissues (leaf appearance rate and leaf and stem elongation rates) (Table 4).This occurred because the values of all these variables were increased, in the months of the year with favorable climate conditions for pasture growth.

These results agree with those obtained by SANTOS et al. (2010), who found that the weight of the signal grass tiller under continuous stocking was positively correlated with its leaf (r = +0.64) and stem (r = +0.63) elongation rates.

Table 4 - Pearson linear correlations among morphogenetic and structural characteristics of tillers in signal grass pasture under continuous stocking

Variable	LBL	SL	NLL	NDL	NT
LAR	0.84**	0.59***	0.93*	-0.70**	0.64***
PHYL	-0.70**	-0.47***	-0.91*	0.67***	-0.57***
LER	0.84**	0.62***	0.90*	-0.68***	0.58***
SER	0.87**	0.66**	0.91*	-0.73**	0.61***
LSR	0.29	0.63***	-0.08	0.41	0.33
LLS	-0.72	-0.57***	-0.77**	0.59***	-0.49***

LAR-leaf appearance rate; PHYL-phyllochron; LER-leaf elongation rate; SER-stem elongation rate; LSR-leaf senescence rate; LLS-leaf lifespan; LBL-leaf blade length; SC- stem length; NLL-number of live leaves; NDL-number of dead leaves; NT-number of tillers; *Significant by t test (P <0.01); **Significant by t test (P <0.05); ***Significant by t test (P <0.10).

Nevertheless, the number of dead leaves per tiller correlated positively with those response variables that show smaller tissue flow and lower growth rate, such as phyllochron and leaf lifespan (Table 4).This occurred because the values of these variables were increased together in the months of the year with unfavorable weather for grass growth.

It is important to emphasize the positive association between LAR and the number of signal grass tillers (Table 4). This result is justified considering that the greatest LAR is a precondition for the emergence of tillers in pasture. In other words, when a new leaf is synthesized, there is the concomitant formation of a new axillary bud, with the potential to originate a tiller (NELSON, 2000). Thus, the increase in LAR during favorable climate months (Table 1) can stimulate grass tillering, which ensures its stability and forage production.

Other positive and consistent relationships occurred between LER and LBL, as well as between SER and SL (Table 4). In fact, the greatest synthesis and/or cell elongation occurred in the organs of the plant, especially in months with favorable climate for pasture growth and development, contributes to increase the size of these organs. In fact, BRAZ et al. (2010) found a linear increase of leaf blade length of signal grass depending on its leaf elongation rate and a linear increase of the stem length in response to its increased elongation rate.

As mentioned before, the LSR showed no correlation (P> 0.10) with most of the structural characteristics of signal grass. In fact, only the stem length was positively correlated with LSR (Table 4). In general, in tropical pastures, some conditions in which there is greater leaf senescence also results in tillers with longer stems, and one of these conditions is the shading inside the canopy, common in pastures with greater height, such as the pastured managed in this study at 25 cm high during the winter (SANTOS et al., 2011).Under shading, leaf blades, especially the older and the ones with lower insertion level in the tiller, hit the light compensation point and senesce (HODGSON, 1990). At the same time, shading triggers high light competition among tillers, taking the plant to prioritize the carbon allocation to the internodes elongation, in order to position the new leaf area in the least shaded layers of the canopy (CARNEVALLI et al. in 2006).

These arguments were also used by BRAZ et al. (2010) to justify the positive correlation of leaf senescence rate with stem elongation rate in signal grass plant at varying heights on the same pasture managed under continuous stocking by cattle.

Although a positive correlation between LSR and the number of dead leaves per tiller was expected (Table 4), it did not happen (P> 0.10). This may be due to the methodology used in this study, in which the leaves were considered dead only when the senescence process exceeded more than 50% of the leaf blade length. Thus, in many cases, there was a measurement of senescence only in the apical portion of the leaf, but many leaves continued to be classified as alive.

Regarding associations among the structural characteristics of signal grass, the leaf blade length (LBL) correlated positively with stem length (SL) (Table 5). Pasture managed at higher height (25 cm) showed that tillers had longer stems during winter and spring, compared to pasture maintained at 15 cm in winter (SANTOS et al., 2011). In these longer tillers, the youngest leaves need to go a longer way through the pseudostem to expose itself. Thus, the distance crossed by a leaf from the point of connection to the meristem until the end of the pseudostem is longer, resulting in its greater length

(SKINNER & NELSON, 1995).

In general, the correlations were positive among the structural characteristics that refer to the number and size of living organs of tillers, which are: LBL, SL, number of live leaves (NLL) and number of tillers (NT). Furthermore, these characteristics are negatively correlated with the number of dead leaves per tiller (NDL) (Table 5).

Table 5 - Pearson linear correlations between structural characteristics of tillers on Brachiaria grass pasture under continuous stocking

Variables	LBL	SL	NLL	NDL	NT
LBL	-	0.85*	0.73***	-0.61***	0.46
SL		-	0.43	-0.26	0.14
NLL			-	-0.79**	0.58***
NDL				-	-0.56***
NT					-

LBL-leaf blade length; SC- stem length; NLL-number of live leaves; NDL-number of dead leaves; NT-number of tillers; *Significant by t test (P <0.01); **Significant by t test (P <0.05); ***Significant by t test (P <0.10).

In spring and summer months, the organs of the shoot of the tillers (leaves and stems) expressed higher growth rates (SANTOS et al., 2011) and, thus, reached higher lengths. Likewise, the NLL and NT were also high in these seasons due to climatic conditions favorable for plant growth. Therefore, the correlations between these variables were positive (Table 5). In this sense, SANTOS et al. (2010), working with signal grass at varying heights in the same pasture, also found that the correlations were positive between the weight of the tiller and leaf blade (r = 0.66) and stem (r = 0.82) lengths, and the number of live leaves per tiller (r = 0.69).

However, the lowest NDL during the seasons when the grass showed higher growth and size of their bodies (spring and summer) (SANTOS et al., 2011) explains the negative correlation of NDL with other structural features. Probably because of the increased length of the leaf blade during spring and summer, the leaves took longer to present more than 50% of senescence and, thus, fewer leaves were considered dead.

The data here presented allow us to infer that the signal grass modifies its morphogenetic and structural characteristics in a dynamic and interactive way in order to adapt to changes in environmental conditions, including climate and grazing management. In this sense, the study of correlations identified the nature of the relationships or associations among the responses obtained by morphogenetic assessment, which is of great value to better understand the responses of forage plants in pasture ecosystem

CONCLUSION

Grazing management, designed seasonally through the lowering of signal grass pasture to 15 cm in early winter and its subsequent increase to 25 cm in early spring, was advantageous compared to the maintenance of pasture at a fixed height (25 cm on average) during the seasons.

The sizes and numbers of the organs of the shoot of *Brachiaria decumbens* cv. Basilisk as well as their growth rates are positively correlated.

On *B. decumbens* pasture under continuous stocking the following relationships occur: 1) compensation between leaves appearance and lifespan; 2) positive correlation between leaf appearance rate and number of tillers; and 3) positive association between stem length and leaf senescence rate.

B. decumbens modifies its morphogenesis to adapt to changing environmental conditions, including climate and grazing management.

REFERENCES

BRAZ, T.G.S.; SANTOS, M.E.R.; GOMES, V.M.; CASTRO, M.R.S.; FONSECA, D.M. Interdependência entre características do fluxo de tecidos do capim-braquiária. **Enciclopédia Biosfera**, v.6, n.10, p.1-12. 2010.

CÂNDIDO, M.J.D.; GOMIDE, C.A.M.; ALEXANDRINO, E.; GOMIDE, J.A.; PEREIRA, W.E.

Morfofisiologia do Dossel de *Panicum maximum* cv. Mombaça sob Lotação Intermitente com Três Períodos de Descanso. **Revista Brasileira de Zootecnia**, v.34, n.2, p.406-415. 2005.

CARNEVALLI, R. A.; DA SILVA, S. C.; BUENO, A. A. O.; UEBELE, M. C.; BUENO, F. O.; SILVA, G. N.; MORAES, J. P. Herbage production and grazing losses in *Panicum maximum* cv. Mombaça under four grazing managements. **Tropical Grasslands**, v. 40, n. 3, p. 165-176, 2006.

CHAPMAN, D.F., LEMAIRE, G. Morphogenetic and structural determinants of plant regrowth after defoliation. In: BAKER, M. J. (Ed.). **Grasslands for Our World.** SIR Publishing, Wellington, p.55-64, 1993.

EMBRAPA. **Sistema brasileiro de classificação dos solos**. Brasília: Embrapa-SPI; Rio de Janeiro: Embrapa-CNPS, 1999. 412p.

FAGUNDES, J.A.; SILVA, S.C.; PEDREIRA, C.G.S.; CARNEVALLI, R.A.; CARVALHO, C.A.B.; SBRISSIA, A.F.; PINTO, L.F.M. Índice de área foliar, coeficiente de extinção luminosa e acúmulo de forragem em pastagens de *Cynodon* spp. sob lotação contínua. **Pesquisa Agropecuária Brasileira**, v.36, n.1, p. 871-195, 2001.

FAGUNDES, J.A.; FONSECA, D.M.; MISTURA, C.; MORAES, R.V.; VITOR, C.M.T.; GOMIDE, J.A.; NASCIMENTO JUNIOR, D.; CASAGRANDE, D.R.; COSTA, L.T. Características morfogênicas e estruturais do capim-braquiária em pastagem adubada com nitrogênio avaliadas nas quatro estações do ano. **Revista Brasileira de Zootecnia**, v.35, n.1, p.21-29, 2006.

HODGSON, J. **Grazing management – science into practice**. Essex: Longman Scientific & Technical, 1990, 203p.

KÖPEN, W. **Climatologia.** Buenos Aires: Gráfica Panamericana, 1948.478p.

MORAES, R.V.; FONSECA, D.M.; NASCIMENTO JR.; RIBEIRO JR, J.I.; FAGUNDES, J.L.; MOREIRA, L.M.; MISTURA, C.; MARTUSCELLO, J.A. Demografia de perfilhos basilares em pastagem de *Brachiaria decumbens* adubada com nitrogênio. **Revista Brasileira de Zootecnia**, v.35, n.2, p.380-388, 2006.

NELSON, C.J. Shoot Morphological Plasticity of Grasses: Leaf Growth vs. Tillering. In: LEMAIRE, G.; HODGSON, J.; CARVALHO, P.C.F.; NABINGER, C. (Eds.) **Grassland ecophysiology and grazing ecology.** CAB-International, Wallingford, UK, p.101-126, 2000.

NOVAES, R.F.; SMYTH, T.J. **Fósforo em solo e em condições tropicais**. Viçosa: UFV, DPS, 1999. 399p.

PARSONS, A. J. The effects of season and management on the growth of grass swards. In: JONES, M. B.; LAZENBY, A. (Ed.). **The grass crop**: the physiological basis of production. London: Chapman and Hall, 1988. p. 129-177.

SANTOS, M.E.R.; FONSECA, D.M.; SILVA, S.P.; GOMES, V.M.; ALBINO, R.L. Associações entre características morfogênicas e estruturais do capim-braquiária com alturas variáveis no mesmo pasto. **Enciclopédia Biosfera**, v.6, n.10, p.1-10. 2010.

SANTOS, M.E.R.; FONSECA, D.M.; GOMES, V.M.; GOMIDE, C.A.M.; NASCIMENTO JR, D.; QUEIROZ, D.S. Capim-braquiária sob lotação contínua e com altura única ou variável durante as estações do ano: morfogênese e dinâmica de tecidos. **Revista Brasileira de Zootecnia**, v.40, n.11, p.2323-2331. 2011.

SKINNER, R.H., NELSON, C.J. Elongation of the grass leaf and its relationship to the phyllochron. **Crop Science**, v.35, n.1, p.4-10. 1995.

WRIGHT, I. J.; REICH; WESTOBY, M. et al. 2004. The worldwide leaf economics spectrum. Nature 428:821–827.

UNIVERSIDADE FEDERAL DE VIÇOSA – UFV. **SAEG – Sistema de análises estatísticas e genéticas**. Versão 8.1. Viçosa, MG: 2003. (Apostila).

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